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ABSTRACT

Mathematics anxiety and competence of 57 Anglo and Hispanic pre-service teachers were measured before and after a 30-hour workshop using the training program EQUALS. Students were divided into three groups: elementary, secondary, and library media. Students in the library media class served as the control group; the other two groups were the experimental groups. Information was gathered on the students' sex, ethnicity, age, college grade point average, and ACT math score. Before beginning student teaching assignments, students were given mathematics and attitudinal pretests and participated in a series of activities leading from single computational problems to more complicated word problems. The EQUALS program emphasized problems solving and group interaction. Post-tests were administered at the end of the student teaching assignments. Anxiety levels did not change, but mathematical competence increased for the group as a whole. Hispanic students showed higher anxiety levels and lower performance levels on both pre- and post-tests. No significant correlation was found between math performance and anxiety level. The success of the EQUALS program for increased mathematical competence was demonstrated for Hispanics and Anglos, males and females. Appendices contain most frequently missed mathematical test questions and samples of mathematical test questions. (LFL)

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EFFECTS OF A MATHEMATICS INTERVENTION PROGRAM ON THE COMPUTATIONAL SKILLS AND ATTITUDES OF PRESERVICE ELEMENTARY AND SECONDARY TEACHERS

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New Mexico is a center for advanced scientific work in energy, computer research and space technology and it is also a state with a growth area for high technology industries. Additionally, New Mexico is the home of the oldest and most traditional cultures in the United States. Hispanics compose over 40 percent of the state's population which also includes an American Indian population of 9 percent. Data on these two groups present a pattern of inequality in terms of social, economic and educational opportunities. For example, 30 percent of all Hispanic adults in New Mexico's rural areas have dropped out of school while the dropout rate for American Indian adults is 50 percent (Sher, 1978). New Mexico is a rural state as well and rural women in New Mexico face triple barriers in overcoming educational and occupational stereotypes. These barriers include their rural residence, their gender, and their minority status (Amodeo, 1982). Today, rural women, like their urban counterparts, increasingly find themselves as heads of households working outside the home to survive. As a result, greater numbers of them continue to enter the labor force. They are largely confined to low-paying, low-status, and unskilled jobs in clerical, service, or seasonal occupations (Chu, 1980).

A decade of research, programmatic activity, and evaluation has provided educators with knowledge about why females and minorities are under-represented in mathematics

and science (Aiken, 1970; Armstrong, 1981; Becker, 1981; Brush, 1980; Casserly, 1975; Ernest, 1976; Fox, Fennema, & Sherman, 1977; Fox, Brody, & Tobin, 1980; Hilton & Berglund, 1974; Parsons, 1981; Sherman, 1981; Steel & Wise, 1979). The major factors associated with attracting and retaining females and minorities in mathematics are related to these students' perceptions of the utility of mathematics in their future lives, their perceived confidence in their ability to be successful in doing mathematics, and the expectations that parents and teachers have for the student's math involvement.

Few minority students are acquainted with successful professionals in mathematics-based careers, such as engineers, physicists or mathematicians, and there are very few role models. Consequently, most are unaware of the career possibilities that proficiency in mathematics might open for them. In many cases their families and teachers are similarly unaware of these possibilities and therefore do not encourage the students to concentrate on mathematics and science.

DESIGN BACKGROUND

Descriptions and evaluations of effective programs indicate what can be done to address this problem (Aldrich & Hall, 1980; Brody & Fox, 1980; Chapline, Newman, Denker, & Tittle, 1980; Cook & Kersh, 1980; Downie, Slesnick, & Stenmark, 1981; Fennema, Becker, Wollear, & Pedro, 1980;

Fraser, 1982; Kreinberg & Stage, 1981; Smith, 1982; Taylor, 1979; Weiss, Pace, & Conaway, 1978). Research with rural and minority students in the Southwest shows that these students stereotype occupations and do not associate women's employment with changes in family life (Dunne, 1980). Intervention programs that develop students' awareness of the importance of math to future options, increase their confidence and competence in doing mathematics, and encourage their persistence in mathematics have the best chance of success.

The design of this study reflects the research on educational and career choices and our own five-year experience in conducting training institutes in multicultural, nonsexist curriculum development and science and math workshops for teachers. Dunne's research (1980) indicates that educational and career choices are shaped by curriculum and by attitudes developed during the school years. Another finding of Dunne's study is that the classroom teacher is a key influence on the occupational preferences and choices of rural and minority students. Unfortunately since many teachers do not feel comfortable teaching mathematics, their negative attitudes about mathematics influence their students.

In 1974, the Lawrence Hall of Science, University of California at Berkeley, began working to reverse the pattern of math avoidance among females and minorities through

teacher training workshops and classes. Beginning in 1977, one particular program entitled EQUALS has focused on the attraction and retention of women and minority students in mathematics. Fifteen hundred California teachers have participated in 30 hour inservice workshops that provide methods and materials which build confidence and competence in teaching mathematics and in improving students' attitudes toward mathematics.

METHOD AND DATA SOURCE

Subjects

Originally, 203 students were identified to participate in the study. Because of the emphasis that was placed on anonymity through the use of social security numbers, we found that in taking the math pre test or the anxiety pre test many of the students had failed to write their social security numbers. The following description of the subjects includes those students for whom we had all complete and necessary information.

The sample included 57 pre-service teachers enrolled in a student teaching block. The students were divided into three groups: elementary, secondary and library media. The students in the library media class served as the control group while the other 2 were the experimental group.

Information was gathered on all 57 students related to sex, ethnicity, age, college GPA and ACT math scores. The data in Table 1 depict the ethnic composition of the group

as well as their sex. Since the two largest ethnic groups are Anglos and Hispanics, information regarding other ethnic groups does not appear. Nevertheless, within the group there were one female black and one male Indian.

(Insert Table 1)

Looking at each individual group we found that in the secondary group there was a higher percentage of males (61%), and in the elementary group there was a higher number of females (94%). The library media group, which was composed of both elementary and secondary education students, had 65% females and 35% males. The ethnicity of the three groups was comparable to that for the total group in Table 1.

As far as age is concerned, there was a wide range, from 22 years old to 54 years old. As can be seen in Table 2, there were three age ranges, the youngest range having the largest number of students. It is not surprising to find a substantial number of older students (31) since we are seeing a trend of older students returning to universities to get their teaching certificate after they have received a B.A. or B.S. in areas outside of education.

(Insert Table 2)

Information on their college GPA was compiled. The averages ranged from a low of 2.287 to a high of 3.723. Table 3 has information related to the groups' mean GPA broken down by ethnicity and sex within the control and experimental groups.

(Insert Table 3)

Table 1
Gender and Ethnic Composition of Group

	Anglo	Hispanic	TOTALS
Male	15 26%	6 11%	21 37%
Female	28 49%	8 14%	36 63%
TOTALS	75%	25%	57

Table 2
Ages of Total Group

	Age Range		
No. of Students	22-28	29-35	36-42
	38	25	6

Table 3
College GPA by Sex, Group and Ethnicity

	Control		Experimental	
ETHNICITY	SEX		SEX	
	M	F	M	F
ANGLO	2.66	3.24	3.15	2.97
MINORITY	2.40	2.85	2.94	2.95

As can be seen, there were no significant differences in mean GPA scores in regard to group, sex or ethnicity. This perhaps is a reflection of the uniform type of training that students receive and the type of student which enrolls in ENMU's School of Education. There may exist differences from year to year in students as a group as is perhaps reflected in the control group which is composed of students who are from a year to a semester behind the experimental group.

Scores on the math portion of the ACT were gathered for all 57 students. The range on the ACT math scores was from 1 being the lowest to 30 the highest.

(Insert Table 4)

Data in Table 4 show that the mean scores for the female/minority students was five to six points lower than any of the other 3 categories. While the differences may not be significant, it is still an indication that women and especially minority women tend to score lower on math tests.

DESIGN

Procedures

Both the control and the experimental group were given a math pre and post test as well as a pre and post test on attitudes about mathematics. Participants in the experimental group were asked to answer four questions related to the appropriateness and usefulness of the treatment to their student teaching experience. Students remained anonymous,

Table 4
Mean ACT Scores by Sex and Ethnicity

	Anglo	Minority
Male	16	15
Female	15	10

and all data was gathered through the use of their social security number.

The treatment consisted of a 30-hour workshop which included a variety of activities designed to build confidence and competence with teaching mathematics and to improve students' attitudes towards mathematics.

Since the experimental group was composed of both the elementary and secondary student teachers, a decision was made to keep both groups separate so that the numbers would be manageable. Because the treatment required a series of small group activities, this decision was deemed appropriate after space and location of workshop were considered.

The math and anxiety pretests were administered at the beginning of the semester. The treatment was done a week before the students went into the public schools to do their student teaching. The math and anxiety post tests as well as the questionnaire were administered the last week of the semester. All student teachers are required to be in the public schools for a minimum of twelve weeks.

MATERIALS

Treatment

The treatment consisted, as mentioned before, of a 30-hour workshop in which the experimental group received training through the use of EQUALS. EQUALS is a program developed in 1977 by the Lawrence Hall of Science at the University of California at Berkeley through funds from the

Carnegie foundation which focuses on the attraction and retention of women and minority students in mathematics. The program is designed to provide training in three areas: awareness, competence and confidence. It is composed of a series of activities dealing with simple computational problems to more complex word problems. It includes math stations which are displayed and changed throughout the workshop. Participants are encouraged to go to the stations before and after the workshop and during the breaks.

Other activities which are included are startling statements which are a series of questions related to numbers and percentages of women and minorities in different occupations. Participants are asked to estimate or guess the answers and give a mean and range for their answers. This is followed by a discussion of data gathered.

A unique aspect of many of the EQUALS activities is that they are done in small groups. The goal is to instill in teachers the idea that it is "all right" to let students work out problems in groups. That a group's solution to a problem is important but that the interaction and cooperation that takes place is perhaps more important. By working in groups, students gain confidence in their abilities to do math and reduce their anxiety levels.

Another important aspect of the EQUALS training is the importance that is placed on the process of solving mathematical problems, not the answer. Answers in general are

not provided. Participants are encouraged to focus on the sequence that they followed in trying to solve the problem and to forget about whether they have or do not have the correct answer.

At the end of the 30-hour workshop, participants have moved from awareness activities such as startling statements, to group activities which lead to competence and to building up their confidence in working with math.

One of the areas of math which is stressed through EQUALS is that of word problems. In our work with teachers we have found, especially at the elementary level, that teachers are consistently avoiding word problems. One of the main reasons teachers give for not doing word problems is that they themselves do not feel comfortable with word problems. Through EQUALS, teachers receive training on the use of manipulatives and visuals (beans, blocks, venn diagrams, charts) to help students solve word problems. The emphasis again is to have students work in groups to solve problems.

RESULTS

The statistical analyses focused on two main questions. First, did the intervention appreciably alter the anxiety level and therefore increase the mathematical competence of the experimental group? Second, were there significant differences in the math performance levels and the anxiety levels of the minority and female students as compared to the Anglo and male students?

Several statistical analyses were performed to determine the effects of the intervention. In order to assess the level of mathematical entry ability of the students an item analysis of question difficulty on the mathematical computational test was done. Tables 5, 6, and 7 summarize the results of the item analyses by pre and post test and by groups. The experimental group is composed of group 0 (secondary) and group 5 (elementary). The control group is group 1 (library media). (Examples of the test questions are included in appendices A and B).

(Insert Tables 5, 6 and 7)

There does not appear to be any pattern related to question difficulty and number of students who missed the item. A greater number of students failed questions 23 through 27, but this was probably due to the time factor. The test was timed and many students were unable to complete the entire test in the time allowed.

Table 8 presents the correlation between the pre and post tests of mathematical computation and math anxiety.

(Insert Table 8 here)

While there were no significant relationships between the means of the pre and post tests for groups 1 and 5, Group 0 showed significant differences between the means of the pre with the post test on mathematical anxiety, $t=2.61$ $p<.05$.

Table 5
Ten most frequently missed questions
by group and test. Group 0

GROUP 0			
PRETEST		POSTTEST	
# OF STUDENTS THAT MISSED	QUESTION #	# OF STUDENTS THAT MISSED	QUESTION #
20	24	23	24
18	13	22	26
18	23	21	15
17	11	21	27
16	21	20	23
16	25	20	25
16	27	19	17
15	17	18	13
14	7	18	21
14	15	16	9
GROUP 0 contained 23 students			

Table 6
Ten most frequently missed questions
by group and test. Group 1

GROUP 1			
PRETEST		POSTTEST	
# OF STUDENTS THAT MISSED	QUESTION #	# OF STUDENTS THAT MISSED	QUESTION #
16	24	17	24
16	26	14	17
15	13	14	27
15	27	13	9
14	17	13	26
14	19**	12	13
14	25	11	15
13	15	10	7
11	5	10	21
11*	11	9	23
GROUP 1 contained 17 students			
* More questions exist with the same number of students missing the same amount. **This question only appears once in these charts.			

Table 7
Ten most frequently missed questions
by group and test. Group 5

GROUP 5			
PRETEST		POSTTEST	
# OF STUDENTS THAT MISSED	QUESTION #	# OF STUDENTS THAT MISSED	QUESTION #
17	27	17	24
16	15	16	27
16	24	15	26
16	26	13	21
13	21	12	17
10	3**	11	5
10	5	11	9
10	13	10	15
10	20	10	20
10	25	10	25
GROUP 5 contained 17 students			
**This question only appears once in these charts			

Table 8
Correlation and t-tests between math and anxiety pre and post test

GROUP	Correlation between pre and post test		t-test on exam pre and post test	t-test on anxiety pre and post test
	exam	anxiety	Ho: $\mu 1=\mu 2$	Ho: $\mu 1=\mu 2$
0	+.737	+.310	t=+.871	t=+2.161*
1	+.723	+.167	t=+1.333	t=+.533
5	+.606	+.429	t=+.675	t=+.295
* Is significant at the .05 level				

Contrary to the prediction that there would be a significant correlation between math exam scores and math anxiety scores, Groups 0 and 5 showed no significant correlation. (This is likely due to small $\underline{n}$). Only Group 1 (the control group) showed significant differences between the means of the computation and anxiety pre tests, $t=2.981$, $p<.05$. However, the combined group results were significant, $t=2.858$, $p<.05$. Negative correlations imply that the higher the math score the lower the anxiety score. Table 9 presents the correlation data.

(Insert Table 9 here)

Finally there was a significant difference between the combined groups' performance on the pre and the post math exams. The mean number of questions answered correctly increased, $t=1.760$, $p<.05$. There were no significant differences in the means of the pre and post anxiety tests.

(Insert Table 10 here)

In terms of the second question, whether there were significant differences on the computation test between cultural groups and male and female subjects the data are presented in Table 11. The results are discussed below.

(Insert Table 11 here)

As was predicted the mean score for the Hispanics on the mathematical computation test was significantly lower than the mean score of the Anglo group, $t=2.106$, $p<.05$. After the treatment, the mean score for the Hispanic group

Table 9

Correlation between math and anxiety pre and post tests

GROUP	Correlation between exam and anxiety scores		HO: RHO=0 (probability that correlation is due to chance)	
	pre	post	pre	post
0	-.310	-.061	t=-1.263	t=-.237
1	-.610	-.414	t=-2.981*	t=-1.761
5	-.178	-.310	t=-.701	t=-1.263
Combined group				
	-.378	-.253	t=-2.858*	t=-1.831
* Is significant at the .05 level				

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Table 10
Means, Standard Deviations, and t-test
on math and anxiety pre and post tests

COMBINED GROUP TESTS			
EXAM	MEAN	STANDARD DEVIATION	t-TEST
PRE	14.16	4.81	t=+1.760*
POST	15.80	4.60	
ANX			
PRE	11.76	9.30	t=+1.404
POST	9.33	8.18	
* Is significant at the .05 level			

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Table 11

Means and t-tests by group and sex

GROUP	CASES	MEANS		t-TESTS		
		PRE	POST	WITHIN GROUP	BETWEEN GROUPS **	
					PRE	POST
Hispanic	14	10.07	13.93	t=+2.106*	+3.518*	+1.444
Caucas	41	15.32	16.05	t=+0.725		
Other	2	16.5	18			
Male	21	11.90	15.24	t=+1.839*	+1.818*	+0.395
Female	36	14.56	15.81	t=+1.302		

* These tests are significant at the .05 level

** These tests do not include the group titled other

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as compared to the mean score of the Anglo group was no longer significant (yet lower).

Contrary to expectations, the male students had a lower mean score on the pre-test (11.90) than did the female students (14.56), $t=1.839$, $p<.05$. The post test mean scores were not significantly different with males achieving 15.24 and females 15.81.

DISCUSSION

Previous research studies have provided information related to the performance levels of females and minorities as compared to Anglo males in mathematics. With few exceptions, the studies have consistently indicated that Anglo males achieve at a higher level than do minority males and females in mathematics. Little information is available regarding intervention programs in mathematics for preservice teachers particularly minority student teachers. Previous EQUALS' research has addressed inservice teachers and has not specifically looked at difference in cultural groups.

The results of this study support the effectivensss of intervention programs with minority preservice teachers. While the study did not find that the female students were lagging behind the males, the success of the EQUALS treatment for increased mathematical competence was apparent across all groups.

Several outcomes of the study warrant further discussion. Programs that help eliminate some of the math anxiety usually remove some of the mental blocks that interfere with mathematical computations. Since there was no apparent pattern to the types of questions missed and the same questions were not missed at the same rate on the pre and post tests,it seems possible that the students knew the correct procedures, formulas, and computational methods but were not able to respond correctly because of other factors.

The effects of the intervention on the Hispanic sample are particularly interesting. Use of manipulatives and divergent explanations of mathematical processes provide illumination for students with different learning styles and cultural backgrounds. Further research needs to be conducted with a variety of cultural groups to determine whether the effects can be replicated across cultures.

Implications for further research include examining the differences in male and female achievement in mathematics at the university. Current research supports the reversal theory which indicates that males fall behind females in math achievement up to the sixth grade where the reverse occurs and then continues throughout high school. Additional research is needed to determine whether that is, in fact, the case.

This discussion has indicated several areas for further research. Currently the study is being extended to

include only elementary preservice teachers and a control group: however, former students will be involved in examining the effects of EQUALS intervention on public school children. If we are to successfully change the traditional approaches and results of our educational system, we must start with young students who are relatively free from the influence of stereotyping.

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Questions most frequently missed:

1. Write in factorial notation: 71 . 8 . 9

2. Write "prime" or "composite" for the number 70.

3. A cube has A on 3 faces, B on 2 faces, and C on 1 face. Give the probability for: P(A).

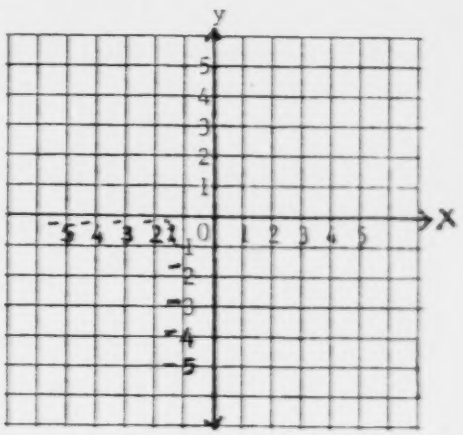
4. $\sqrt{78}$ =

5. Science Scores: 78, 89, 9[illegible], 87, 82, 85, 79, 90
The range is:

6. Find the area of the parallelogram: b = 8cm, h = 6cm, Area =

7. Complete the table of values and graph the equation, y = 2x - 1.

x	-2	-1	0	1	2
y					



8. Write and solve an equation for: 30% of a number is 21. What is the number?

9. Choose the condition -- SSS, SAS, ASA -- that shows that the triangle is congruent.

10. A parking lot is 20m long and 17 m wide. What is its area?

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Samples of questions:

1. Round to the nearest hundredth: 4.173 = _____

2. $(4 = 6) + 3 = 4 + (6 + 3)$ Which basic principle for addition is illustrated? Commutative, associative, or zero?

3. Find the quotient to the nearest tenth. $1.5\overline{)5}$

4. $2x - 4 = 6$, $x =$

5. Give an improper fraction for the mixed numeral: $2\frac{1}{4}$

6. $\frac{5}{6} = \frac{n}{24}$, $n =$

7. Write the percent as a lowest-terms fraction or mixed numeral. 75%

8. $6 - {}^{-}6 =$

9. $6c - 10 = {}^{-}28$, $c =$

10. $(42 - {}^{-}7) + 6 = n$, $n =$